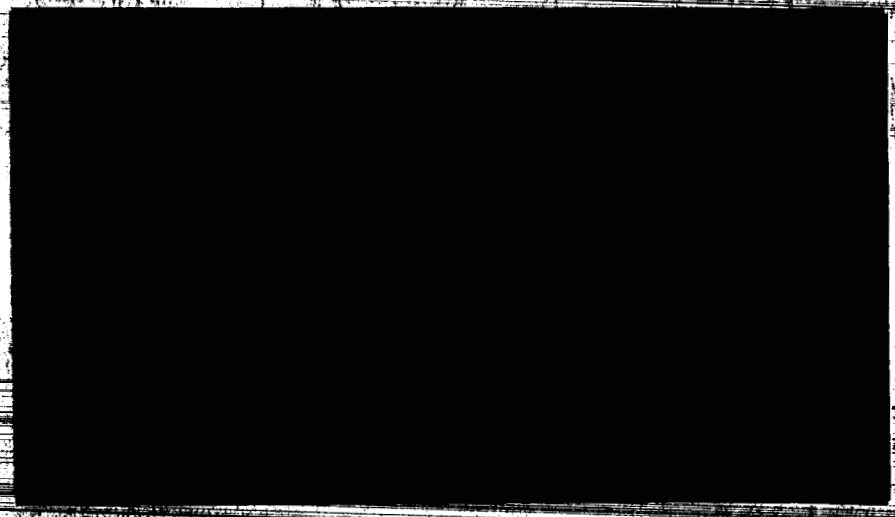

RADIO ASTRONOMY OBSERVATORY

DEPARTMENT OF PHYSICS
FLORIDA STATE UNIVERSITY
TALLAHASSEE, FLORIDA

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to

National Aeronautics and
Space Administration

from

Department of Physics
Florida State University

Radio Astronomy Program

Period

February 1, 1967 through July 31, 1967

Submitted by

C.H. Barrow

Principal Investigator

Abstract

Jupiter observations were continued into April 1967 during the last apparition. A new technique extended the millisecond pulse observations to a time resolution of 0.2 ms and left- and right-hand components of polarization were studied by this technique. Some periods of apparently random-linear polarization appear to be made up of very fast successive pure left- and right-hand circularly polarized bursts when examined with this resolution.

18 Mc/s observations of both axial ratio and polarization fraction have been analyzed and compared with two component observations made in the past and with the predictions of theory. Instrumental effects and errors have also been examined. A detailed account has been submitted for publication. Radio beacon satellite observations have been utilized in assessing the effect of Faraday rotation in the Earth's ionosphere.

A second catalog of Jupiter observations (1965-67) has been prepared and is in press at the time of writing.

A search for decameter-wave radiation for Saturn has been commenced using the Arecibo reflector and also the phase-switched interferometer at Tallahassee. The latter has been enlarged to ten whole wave dipoles in each array, steerable in the north-south direction by means of a travelling wave feed system.

1. Polarization

Measurement of three parameters of polarization of the Jupiter emission at 18 Mc/s was begun during the 1965-66 apparition and continued during the 1966-67 apparition. Morrow established an analysis procedure during 1966 as part of his M.S. thesis.

All of the data has been studied and all major events of the necessary quality to maintain $\pm$15% or better accuracy in axial ratio r and polarization fraction m have been analyzed in detail.

An error analysis by Morrow indicated that the major source of error in the analysis of an event was the calibration of the record. The calibration procedure was simplified and improved in time for the 1966-67 apparition.

The method of analysis has been to calculate m and r for each burst and to present normalized distributions of these quantities.

The distributions indicate that some 45% of the bursts are circularly polarized and that the degree of polarization is generally rather high, some 80% of the bursts having polarization fractions greater than 0.7. The overall accuracy of the measurements is discussed; also the effect of assuming complete polarization in two component measurements. A number of the circularly polarized bursts appear to be mixed with a randomly polarized component and thus would appear as elliptically polarized when only left- and right-components are measured. Allowing for this effect, the results are shown

to be consistent with some of the predictions of the Doppler-shifted cyclotron theory and in good agreement with two component measurements made previously by various workers.

Since the analysis of an event is not automated and the number of bursts may be quite large, the procedure is both tedious and time-consuming. The study by Morrow also established an approximation technique that could be useful in the future.

2. Millisecond pulses

The study of millisecond pulses has been extended by Torgersen, to an overall time resolution of 0.2 ms. for two components of polarization. It appears that at least two different types of pulses can be distinguished; groups where the pulses are randomly distributed in time, and groups of quasi-periodic pulses. The general pulse shape seems to be different in the two types. When studying the LH and RH polarized components of the pulses it was found that the random type pulses were mostly unpolarized and appeared simultaneously and with equal strength in the two channels. The polarization of the quasi-periodic type, however, frequently shifted rapidly from one sense to the other, and the pulse shape in one channel may be quite different from that in the other channel. Without adequate time resolution these pulses appear as random-linear in a two component polarimeter. An example is shown in Figure 1. Studies of these types and of single, double and triple millisecond pulses continue.

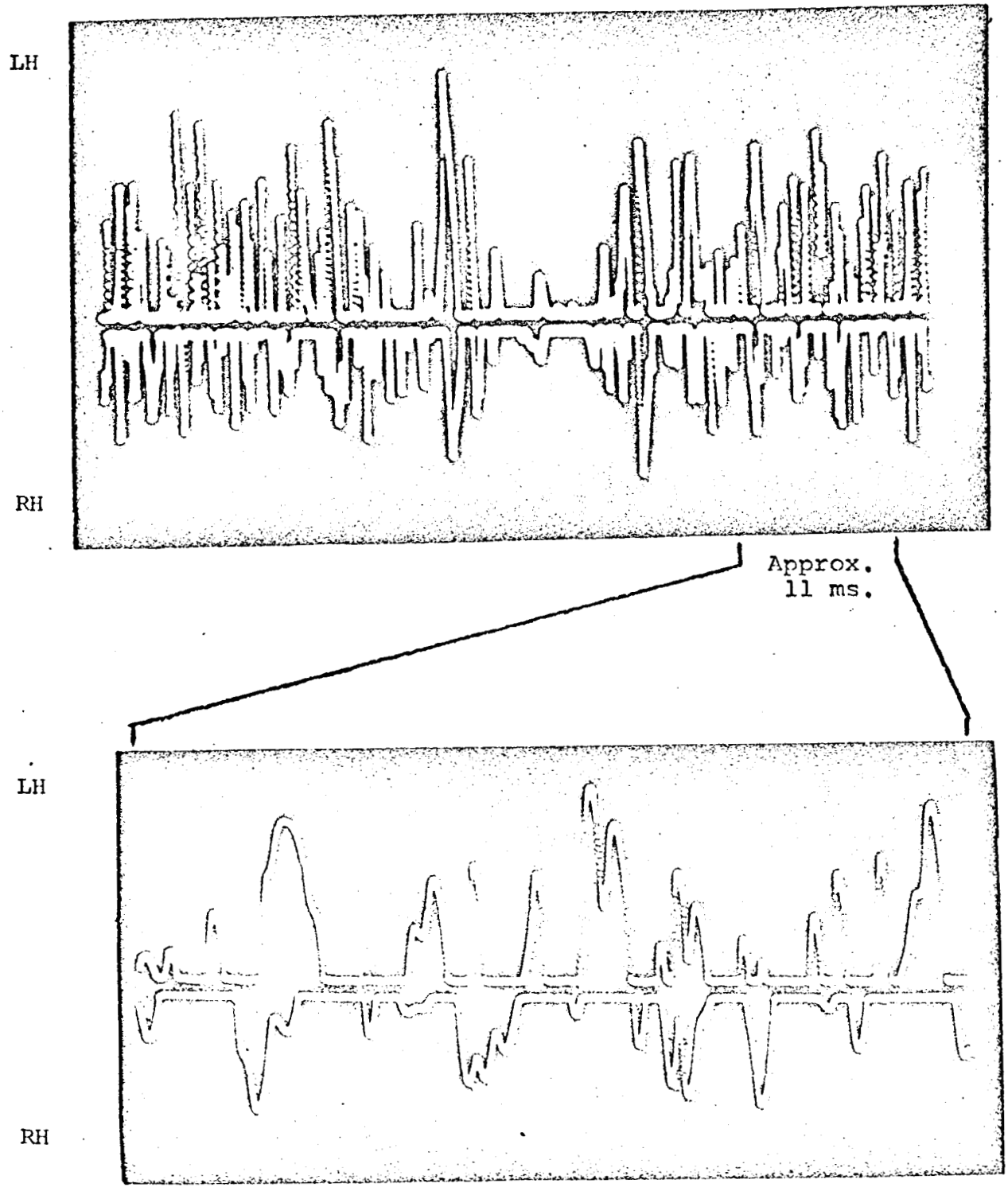

Figure 1.

3. Computing

The Jupiter activity prediction program has been rewritten by Merritt to reduce computer running time and to present the results diagrammatically. It is noted that predictions occur periodically and drift in time across the diagram. The duration of the prediction varies in length in a periodic manner.

In 1958 and 1959 the only two stations observing Jupiter (University of Florida and Yale University) reported very little activity. Running the prediction program in retrospect for these years shows that many of the predictions were of short duration, often only a few minutes, and that the drifts were such as to avoid the observation periods used at these stations on most occasions. Clearly, this is a point that needs to be taken into consideration when assessing lack of activity in solar correlation studies. A note concerning this is in preparation for publication.

The University has just acquired a large area record reader for transferring analog chart records to digital magnetic tape for input to the CDC 6400 computer. This machine will greatly increase efficiency in the detailed examination of high speed records.

The Radio Observatory has leased an IBM 029 card punch.

4. Microfilming and Catalog

Editing of records for microfilming for the NASA Space Data Center has continued. A catalog of Jupiter activity for the apparitions of 1965-66 and 1966-67 has been prepared and is now in press.

Observation times and periods of activity are listed by frequency. Histograms of 18 Mc/s occurrence probability and Io effect are included.

5. S-66 Satellite Observations

During the 1966-67 apparition of Jupiter, observations of the two ionospheric beacon satellites, BE-B and BE-C, were conducted by Thompson during periods of predicted decametric activity from Jupiter. From these selected satellite observations the integrated electron densities were calculated and used to determine the magnitude of the dispersive effects within the bandwidths of the polarimeters. During the early morning hours Faraday rotation can be as great as 475 radians at 18 Mc/s corresponding to a dispersion of about 3.5° /kc. bandwidth when Jupiter is observed close to the zenith.

Integrated electron density measurements are to be continued during the 1967-68 Jupiter apparition. The number of observations is to be increased in order to determine the extent of the variations of the integrated electron densities and the magnitudes of the errors in the observations.

6. Instrumentation

The 18 Mc/s phase-switched interferometer has recently been enlarged and modified by Resch to allow steering in the north-south direction. The antenna originally comprised two arrays, sixteen wave-lengths apart, each array consisting of four full-wave dipoles fed in phase. The number of full-wave dipoles has now been extended to ten in each array, and a travelling wave feed system has been introduced to obtain the north-south steering. As a consequence of this increased sensitivity and steering capacity, several of the stronger stellar radio sources are observable and are being used to calibrate the interferometer.

The interferometer is being used in conjunction with observations at Arecibo to search for decametric emission from Saturn.

The crossed Yagi antennas have been remounted on the thirty-three foot towers so that they may be directed towards the lower elevation of Jupiter in the next apparition. The mounting has been fixed vertically during the last two apparitions. Alt-azimuth step tracking is possible with these mountings.

Some new two-channel receivers have been designed for the radio-observatory and are being made to specification by Davco, Inc. The receivers are slave-tuned by a common local oscillator and incorporate a number of desirable features in the way of output, tuning, bandwidth, etc. that are not usually found in commercial communications receivers. The two channels will be used for right- and left-hand components at each frequency.

7. Difficulties

There have been no major difficulties encountered during the period reported here.

8. Future Plans

(a) Search for Decameter-wave Radiation from Saturn

An experiment has recently been initiated to try to detect decameter wavelength from Saturn using the following instrumentation:-

(i) Arecibo reflector using two two-element Yagis at 16 and 18 Mc/s crossed on a common boom mounted on Carriage-House 2.

(ii) FSU 18 Mc/s phase-switched interferometer, enlarged to 10 whole-wave dipoles in each array. (Section 6)

(iii) 26 Mc/s swept-frequency antenna array built at Clark Lake by Resch.

As Saturn moves to a northerly declination a search for decameter-radiation is an obvious investigation to make. If such radiation exists, however, it must be weaker than the corresponding Jupiter emission by more than the inverse-square law factor otherwise it would already have been detected with existing Jupiter equipment. The observations at Arecibo are being conducted by Barrow in collaboration with Dr. S. Gulkis (Arecibo-Cornell University) and a signal approximating to 1/20 of a typical Jupiter burst is arbitrarily being taken as what might be expected from Saturn. This approximates to the flux

from Taurus A at the same frequencies and is easily detectable by the Arecibo system which appears (from drift scans of Taurus A) to have a beam width of about $3.^{\circ}5$ and a gain of about 35 db. This signal level is also detectable by both the modified FSU interferometer and the Clark Lake antenna. A total of 50 hours observing time is aimed for at Arecibo but this is unlikely to be completed during the present apparition as it is, at present, only possible to observe for 1^h30^m each night and, of course, other experiments in progress prevent the use of the antenna for Saturn for more than about two or three times per week during August and September, 1967.

As a first analysis procedure all periods of suspected activity are to be included in a histogram type of analysis (similar to that used for Jupiter) based on two central meridian longitude systems arbitrarily defined by the two optical rotation periods for epoch 1967, July 1^d0^h U.T. A computer program has been written for this purpose.

An interesting aspect of this experiment is that it may help indirectly to clarify the Jupiter radiation mechanisms. No matter whether the result is positive or negative a comparison of the known physical properties of Jupiter and Saturn should allow some to be eliminated or retained as possible contributors to the Jupiter radiation process in the light of the eventual Saturn result.

(b) Scintillation Experiment

During the 1967-68 apparition, observations will also be made at two remote, unattended sites. In conjunction with the central observatory, these sites form the vertices of a right triangle with baselines of 9,20, and 22 miles.

Crossed Yagi antennas, with four elements in each of the two perpendicular planes have been installed at the three locations for measurement of the two circular polarization components. Unambigous time marks will be supplied by simultaneously recording, at each of the three sites, the VLF continuous-time transmissions from WWVB in Fort Collins, Colorado.

The separated sites are to be utilized in the study of the inherent structure of the decametric burst activity from Jupiter and to measure the solar wind parameters beyond 1 A.U. from the sun. The baselines are sufficiently long to render ionospheric scintillation effects unresolved between the three stations.

9. Publications, February 1, 1967 through July 31, 1967.

"Report of the Florida State University Radio Observatory", C. H. Barrow, Astronomical Journal, 72, 257 (1967)

"Measurement of Four Parameters of Polarization", D. P. Morrow M.S. Thesis, Florida State University, April (1967)

"The Polarization of the Jupiter Radiation at 18 Mc/s", C. H. Barrow and D. P. Morrow, (paper submitted for publication).

"Evidence of Continuum Emission from Jupiter at 18 Mc/s", C. H. Barrow and J. Williams, (paper submitted for publication)

"A Scanner for Short Sections of Magnetic Recording Tape", H. Torgersen, Review of Scientific Instruments, (paper in press)

"Bursts and Pulses in the Jupiter Decameter Emission", H. Torgersen, Astron. J., (Abstract in press)

"Possible Continuum Emission from Jupiter at 18 Mc/s", C. H. Barrow and J. Williams, Astron, J., (Abstract in press)

"A Catalog of Radio Observation of Jupiter, 1965-67", J. Williams, J. D. Merritt, D. P. Morrow, C. H. Barrow, (Florida State University Report in press)

Talks Given During the Period

"Polarization of the Jupiter Radiation at 18 Mc/s", C. H. Barrow and D. P. Morrow
URSI Spring Meeting, Ottawa, Canada; May, 1967.

"Bursts and Pulses in the Jupiter Decameter Emission", H. Torgersen
AAS Meeting, Yerkes Observatory, Wisconsin; June, 1967

"Possible Continuum Emission from Jupiter at 18 Mc/s" C. H. Barrow and J. Williams
AAS Meeting, Yerkes Observatory, Wisconsin; June, 1967.

"Bursts and Pulses in the Jupiter Decameter Emission", H. Torgersen
Colloquium, University of Florida, Gainesville, Florida; June, 1967

Florida Academy of Sciences, Tampa, Florida, March, 1967
Five papers presented by various members of the Group.

10. Personnel

Ingr. Halvard Torgersen (Norges Tekniske Høgskole) has been working as Research Associate for the Academic Year 1966-67. Mr. J. D. Merritt has been appointed as a full-time staff member. His duties are Computer Programmer and Technician.

There are five graduate students presently working on the project. Three of these are Ph.D. candidates, two are M.S. candidates. Morrow and Williams received the degrees of M.S. in April, 1967.

Personnel Working on the Grant

C. H. Barrow, Assistant Professor and Principal Investigator

H. Torgersen, Research Associate

Graduate Assistants

L. A. Capone
D. P. Morrow
G. M. Resch
D. L. Thompson
J. R. Williams *
J. Buckley

Miss B. Brown, Secretary *
Miss Joyce Jordan, Secretary

Computer Programmer and Technician

J. D. Merritt

Electronics Technician

B. Cunningham *
K. Smith

Undergraduate Assistants

R. Broberg *, R. Camblin *, B. Dow *, J. Hage *, L. Hancock *, J. Herr *, P. Howard *, D. Munro *, D. Padgett *, D. Patronas, B. Rosenblatt *, D. Sankey, B. Shannon *, C. Threatte, J. Van Pelt *, P. Watson, C. Wurst.

*Terminated during the period